General Application Name: Police

Product / Service / Function Name: Crime Analysis and Mapping

P/S/F Description:

Crime analysis and mapping refers to the qualitative and quantitative study of crime and law enforcement information, in combination with socio-demographic and spatial factors, to apprehend criminals, prevent crime, reduce disorder, and evaluate organizational procedures.

Crime analysis and mapping typically involves five areas of investigation and planning: intelligence gathering and analysis, criminal investigation, tactical operations planning and support, strategic planning, and administrative support. Intelligence gathering and analysis deals primarily with long-term research into organized crime, and attempts to gather and integrate disparate information on people, their known locations of activity, and links between people and events. Criminal investigation is the study of serial criminal events, victims, and/or crime scenes, as well as physical, socio-demographic, psychological, and geographic characteristics, to develop patterns that will assist in linking and solving current serial criminal activity. Tactical operations planning and support uses mapping technology to document and study recent criminal events, or to plan for organized responses to future crime events. In contrast with the need to deal with short-term tactical problems, strategic planning develops an understanding of criminal activity and documents long-term patterns and trends so that patrol and investigation can respond through broad-ranging procedures. Finally, administrative support compiles and presents aggregated information for administrative use at the highest levels of government to empower new legislation or support new policies (excerpt from *Introductory Guide to Crime Analysis and Mapping*, by Rachel Boba, COPS office, 2001).

Product / Service / Function

1. Spatial Data

   Minimum Requirements

General Description	GIS Data Layer
Law Enforcement Data	Incident Locations
Land Base / Planimetric Data	Tax Parcels
Natural Features	Parks
	Open Water
Transportation	Street Centerlines
Socio-Political Data	Municipal Boundary
	Police Zone Boundaries
	Fire Stations
	Schools
	Hospitals

Optional Requirements

General Description	GIS Data Layer
Law Enforcement Data	E911 Call Locations/Calls for Service (CFS)**
Land Base / Planimetric Data	Building Footprints
	Street Lights
	Zoning Districts
	Land Use
Natural Features	100-Year Floodplain
Transportation	Street Double lines (Right of Way)
	Public Transit Routes
	Railroads
Socio-Political Data	Zip Code Boundaries
	Census Tracts
	Census Block Groups
	Convenience Store & Retail Centers
	Bars
	Social Service Locations
	Prisons
	Neighborhoods & Subdivisions
Other Data	Digital Orthophotography

**Note: The local law enforcement agency must determine the level of information that is provided to the public, especially when dealing with the location of an incident. The law enforcement agency must weigh the public's right/need to know with the right to privacy of a crime victim and suspect. Therefore, 911 calls for service and incidents are often aggregated into larger groups, such as a block, zip code, police-delineated zone or census block group. This strategy protects the specific information about an incident and provides a summary or total number of events by area.

2. Attribute Data:

Minimum Requirements

General Description	Field Name
Incident Data	Unique Incident Identification Number
	Occurrence Date
	Occurrence Time
	Address
	UCR Code
	Patrol Zone
Person Data	Unique Personal Identification Number
	First Name
	Last Name
	Role
	Age
	DOB
	Race
	Social Security Number

GeoDecisions
11838 Rock Landing Dr., Suite 200
Newport News, VA 23606
757-873-0768
www.geodecisions.com

	Residence Address
	Residence City
	Residence State
	Residence Zip Code
	Related Incident Number
Property/Vehicle Data	Unique Property Identification Number
	Disposition
	Make
	Model
	Year
	Serial Number
	Vehicle Identification Number
	Owner First Name
	Owner Last Name
	Address of Origin
	Address of Recovery
	License Number
	Related Incident Number

Optional Requirements

General Description	**Field Name**
Incident Data	Premise Code
	Dispatch Date
	Dispatch Time
	Day Code
	Hour
	Jurisdictional Nature Code
	Business
	Additional Victims
	Modus Operandi
	Drugs
	Domestic Abuse
	Responding Officer
Person Data	Alias 1
	Alias 2
	Latino (Y/N)
	Height
	Weight
	Build
	Eye Color
	Hair Color
	Hair Style
	Tattoo
	Piercing
	Clothing
	Residence Zip Code
Property/Vehicle Data	Stolen Value

	Recovered Value
	Distinguishing Marks
Drugs	Related Incident Number
	Type
	Quantity
Evidence	Related Incident Number
	Owner First Name
	Owner Last Name
	Address of Recovery
	Unique Property Identification Number
	Description
Demographic	Census data at the Block Group level
	Population, # Households, # Families
	Male Population, Female Population
	Racial and Hispanic/Latino population breakdowns
	Age population breakdowns
	Educational Attainment breakdowns
	Households - # Single Parent Households
	Households - # Owner-occupied, # Renter-Occupied

3. Data Acquisition Options

There are many sources for spatial data that a crime analysis and mapping system requires. As previously mentioned, digital incident data can be obtained from the local law enforcement agency's Records Management System (RMS). An RMS can be as simple as a file cabinet full of the police response reports collected by an officer at the scene of an incident. An RMS is, however, most typically a digital database (ex. MS Access, SQL Server, Oracle, mainframe flat-file) that is used to enter these paper reports into a computer for storage. The RMS can then serve as more than a reservoir of incident reports. It can be utilized to generate summary reports, advanced statistical analysis, or as the 'base' from which 'data' is extracted for mapping. Incident data can either be extracted from the RMS on a regularly scheduled basis and placed into a data warehouse, or the crime analysis and mapping system can link directly to this database. The mapping system is then used to geocode, or spatially locate, each event using a street centerline file or a parcels data layer. A street centerline data layer represents each street in a community by a single line that has attached to it its address range. Tax parcels represent a property by a polygon that has information attached to it pertaining to ownership, address, and other assessment data.

In either case, the address of an incident record is matched to a parcel or location along the street centerline and a point feature is created to represent that event. Tax parcels are typically maintained at the county level. Street centerline data layers of varying qualities can be obtained by a number of vendors. The market is relatively competitive, and prices will vary with quality of the data. Relevant vendors that provide this kind of spatial data on a regional and national scale include: NAVTECH (www.navtech.com), GDT (www.geographic.com), and TeleAtlas (www.teleatlas.com). Geocoding can also be used to create other data layers that use single addresses, such as fire stations, schools, hospitals, bars, prisons, convenience store/retails centers, etc.

Other spatial data layers can be obtained through the Internet from various government sources. Municipal boundaries, zip code, U.S. Census tract and block group boundaries and their attribute

data can be obtained in digital format through the U.S. Census Bureau (www.census.gov). Floodplains can be obtained through the FEMA Web site (www.fema.com).

Land base and planimetric data are typically generated at the county level. County staff may create this data themselves or contract the project out to a consulting firm. This data often includes tax parcels, zoning districts, land use, parks, open water, street double lines (Right of Way), and railroads.

The VBMP orthophotos should be an integral component of a crime analysis and mapping application. The orthophotos will give police a "bird's eye view" of area under their jurisdiction. This will allow the authorities to view the distribution of crimes to identify patterns as well as create more efficient deployment of officers through updated beat maps.

4. Data Conflation Options

Data conflation is a process by which two digital data layers, usually of the same area at different points in time, or two different data layers of the same area, are geographically "corrected" through geometrical and rotational transformations so that the different layers can be overlaid on one another. Also called "rubber-sheeting," this process allows a technician to adjust the coordinates of all features on a data layer to provide a more accurate match between known locations and a few data points within the base data set. A good base layer to use for data conflation is the VBMP orthophotos since many features can be seen or interpreted. The need and processes for conflation vary between sets of data, users, and feature types. Any dataset that is updated independently by different departments can be consolidated through conflation. Within most local governments, individual departments are responsible for maintaining specific datasets within their expertise; therefore, conflation is not often necessary. Often, reprojecting the data into a different coordinate system will take care of the misalignment of different data sets. Most industry-standard GIS software has the ability to perform data conflation. Commonly conflated data layers include: parcels, street centerlines, census boundaries, law enforcement boundaries, and any layer that was built using either the parcels or street centerlines.

Each data layer used for crime analysis and mapping should use the Virginia Base Mapping Project orthophotography for the conflation process. This is vital for data consistency across the state, and facilitates data sharing across jurisdictional boundaries. For example, crime incidents and street centerlines need to be in the same projection in order to perform any type of spatial analysis.

5. GUI / Programming Options:

There are many options for developers of crime analysis and mapping systems. The following are three approaches:

- Standard GIS desktop application that can be customized to the user's needs.
- Existing commercial software.
- Hiring a consultant to develop a custom system from scratch.

Using a standard GIS application often requires a significant amount of training and customization. Whereas the initial cost may be low, the time invested in learning these solutions may generally increase the overall expense of implementation. Standard GIS software packages deliver more robust data integration, analysis, and cartographic capabilities than do other crime analysis applications. They have a greater user support infrastructure that allows users to

overcome problems quickly. Options for using an existing, industry-standard GIS software application that can be customized for crime analysis include those listed in the following table:

Standard GIS Software Vendors

Vendor	Software	Add-ons	Web Address
ESRI	ArcView 3.x	Crime Analysis Extension	www.esri.com
ESRI	ArcGIS 8.x		www.esri.com
MapInfo	Professional v7.0	CrimeInfo Extension	www.mapinfo.com
Intergraph	GeoMedia 5		www.intergraph.com/gis
Autodesk	Map 5.0		www.autodesk.com

There are an increasing number of vendors developing and implementing crime analysis software. These products may often cost more than standard GIS solutions because of the customization that is required to fit the application into the agency's business practices and/or connect to its data source. The advantage is that a tailored law enforcement application provides just the functionality that is needed, decreasing the overall application overhead common to industry-standard GIS software. Options for using an existing, commercial crime analysis and mapping system include those listed in the following table:

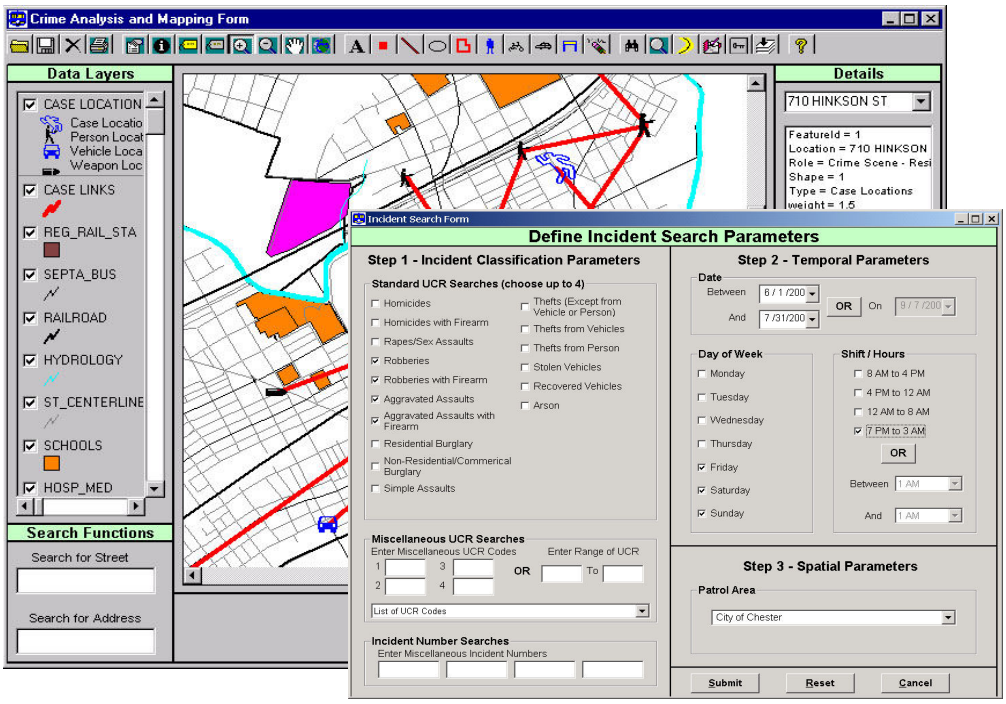
Commercial Software

Vendor	Software	Web Address
GeoDecisions	GeoCAMS	www.geodecisions.com
Omega Group	CrimeView	www.theomegagroup.com
NIJ/ESRI	Community Policing Beat Book	www.esri.com/industries/lawenforce/beatbook.html

The final option for developing and implementing a crime analysis and mapping system is to contract a consultant. This option makes certain that a product will fulfill an agency's requirements. Unlike the first option, which requires the law enforcement agency to modify its own process/technology to fit the system, the system fits existing business practices. A consultant will be able to develop an application that works with the wide range of RMSs that currently exist within the state. Also, training and follow-up user support is often provided at a much more substantial level than with other options.

A crime mapping and analysis can generate a wide variety of useful information. Possible functions include:

- Query law enforcement databases for a certain type of crime and produce a report or map.
- Map and analyze incidents over time.
- Perform correlation analysis between types of crime and the characteristics of the neighborhood.
- Create deployment plans and beat maps for police officers.



A desktop crime analysis application that plots incidents, analyzes patterns, and allows officers and detectives different levels of functionality.

6. Internet Functionality and Options

The Internet has proven itself as a viable solution for law enforcement agencies to centralize the maintenance and management of services and data. As more law enforcement agencies are implementing Web-based solutions, they are finding that the Internet does require them to change the nature of an application or its usefulness. Using the Internet, software can be easily updated, and users gain greater accessibility to the applications and information they need for their specific tasks through simple, user-friendly interfaces.

A true crime analysis application may not be suitable for public viewing on the Internet, due to the confidential nature of the data. However, jurisdictions can summarize statistics with maps or show police beats and crime reduction maps in an interactive Web GIS application. GIS software vendors have products that can be customized in-house or by a consultant to provide distributed applications on the Internet, over an intranet or via wireless network. Basic tools such as zooming, panning and identifying are most often provided to the user for map/data manipulation. However, in more robust crime analysis applications, buffering, temporal charting, and even crime animation can be made available to the user.

GIS Internet Solutions

Vendor	Internet Software	Web Address
ESRI	ArcIMS	www.esri.com/software/arcims
MapInfo	MapXtreme	www.mapinfo.com
Intergraph	GeoMedia WebMap	www.intergraph.com/gis/gmwm
Autodesk	MapGuide	www.autodesk.com
Omega Group	CrimeView Internet	www.theomegagroup.com/crimeview_internet.htm

7. Technical Requirements:

Minimum Technical Requirements
At its most basic level, a crime analysis and mapping system can be used on a single, stand-alone workstation. This workstation would have a hard drive that stores all of the spatial data layers, as well as a database containing a copy of all of the incident records for the law enforcement agency. A typical workstation running off-the-shelf software should have the following minimum specifications:

Processor:	Pentium 3, 450 MHz
RAM:	128MB SDRAM at 133MHz
Hard Disk:	20GB (min.)
Monitor 1:	19"
Floppy Drive:	3.5”
CD-ROM:	12x/8x/32x CD drive
Modem:	56K
OS:	Windows 2000/NT/XP
Office:	Windows 2000 Professional
Printer:	8x11 office-grade color printer

Optimum Technical Requirements:
A more complex crime analysis and mapping system may require multiple components, including servers, desktop workstations, ruggedized laptops, and/or handheld devices. For either a client-server or a Web-based application, the system should rely on a fairly robust server computer and high-end workstations. Example specifications of the necessary equipment are listed below:

Server

Processor:	Min. 2x Processors, 1.7 GHz, 512K cache
RAM:	Min. 2x 512MB RIMMS
Hard Disk:	Min. 2x 80GB +RAID
Monitor 1:	19"
Floppy Drive:	3.5”
CD-ROM:	12x/8x/32x CD drive
Modem:	56K
Network Card:	10/100 mbps

Workstation

Processor:	Pentium 4, 1.5 GHz
RAM:	512MB SDRAM at 133MHz
Hard Disk:	20GB (min.)
Monitor 1:	19”
Monitor 2:	17”
Floppy Drive:	3.5”
CD-ROM:	12x/8x/32x CD-RW drive
Modem:	56K
Network Card:	10/100 mbps
OS:	Windows 2000/NT/XP
Office:	Windows 2000 Professional

Other Components

Printer:	8x11 office-grade color printer and 8x11 production b/w printer
Plotter:	HP DesignJet 1055CM
Tape Backup:	Tape Library Server
UPS:	APC 1400 (or other similar)
Scanner:	11x17
Handheld:	Compaq IPAQ
Network:	T1

8. Administrative/Management Requirements

At the beginning of the project, the assigned project manager of the local law enforcement jurisdiction should consider completing some, if not all of the following tasks that relate to the administrative requirements of a crime analysis and mapping project:

- Determine, with or without the assistance of a consultant hired to develop the system, the preliminary vision and goals of the project.
- Determine the stakeholders (e.g. operational and tactical personnel, detectives, special units) of a crime analysis and mapping project within their own jurisdiction and with larger government entities that they interact with.
- Coordinate an initial stakeholders meeting where the vision and goals of the project are expressed and the background of GIS technology is described, if needed.
- Coordinate with other municipal agencies for data sharing provisions.
- Determine a mechanism of communication to keep the stakeholders aware of the progress of the project.
- Develop a basic understanding of the available precedents in their region/state and research the available technologies that can be applied to their project.

Upon project completion, a simple desktop crime analysis and mapping application will require very little administrative support. Administrative tasks may include loading or upgrading new versions of the software or patches, providing for constant data flow from the RMS, and maintaining yearly support contracts on the hardware and software. However, once the system becomes distributed, there are various other management requirements that need to be fulfilled on a weekly or monthly basis.

At the point where the system grows beyond single desktop users, a devoted administrator or system manager needs to be established. This is essential for the following reasons:

- The system will now be interfacing with other technology systems already in place; therefore someone needs to maintain contact with the technology personnel that maintain these systems.
- The manager needs to put into place quarterly training schedules to maintain user knowledge of the system.
- Funding will undoubtedly be required to either maintain the system long-term, or continue to expand the system, which requires funding research and applications for grants.
- Crime analysis and mapping only succeeds when it is implemented on a weekly basis with rigorous analysis and planning.

9. Costs:

Hardware	Typical Unit Cost
Minimum Workstation	$2,000
Optimum Workstation	$3,200
Laptop	$2,400
Web/FTP Server	$8,500
Database Server	$12,000
Data Warehouse Server	$18,000
Backup Server	$5,800
Printer (8x11 color)	$700
Printer (8x11 b/w production)	$2,000
Plotter	$12,000
Tape Library	$5,000
UPS	$700
Scanner	$1,500
Handheld	$300-$700

Software (all prices included license)	Typical Unit Cost
Standard GIS desktop software	$700-$10,000
Desktop vendor crime analysis and mapping application	$2,000-$6,000
Customized desktop vendor solution	$5,000-$15,000
Web-based vendor application	$15,000-$25,000
Customized web-based vendor solution	$20,000-$60,000

Miscellaneous	Typical Unit Cost
Training – focused vendor crime mapping training (per person)	$700-$1,000
Training – general GIS	$700-$1,200
Licensing – desktop	$100-$500
Licensing – web app (1st CPU)	$7,500-$12,000
Maintenance (per year)	$8,000-$15,000

10. Standards / Guidelines Summary

- Always maintain a unique identification number with every incident, spatial feature, and event recorded within the system.
- Standardize street naming conventions to make certain of proper geocoding.
- If there are multiple streets with the same name (e.g., Main St.) then standardize additional fields, such as borough name or zip code, that are collected to differentiate the streets.
- Create standard Common Place-name file. For example:

Common Name	Address
McDonald's	236 Johnson St
Grant Statue	14th St. & Willits St
Central Park	1500 Warrington Rd
The Pit	6550 Templeton Ln

K&A	Kensington Ave & Allegheny Ave

- Standardize Person and Property Identification Number (at least eight characters).
- Collect zip code for all incidents. This facilitates cross-jurisdictional information sharing.
- Standardize use of Uniform Crime Reporting codes statewide.
- Standardize date and time conventions.
- Develop a detailed Quality Assurance/Quality Control (QA/QC) procedure for reviewing the accuracy of the GIS data and its attributes.
- Maintain data in the VBMP standard coordinate system (Virginia State Plane, NAD 83, Survey Feet).
- Create metadata (standard information about GIS data) for each data layer. Metadata tracks the date, origin, coordinate system, and other such information for data layers.

11. Startup Procedures/Steps

There should be a minimum of eight steps involved with a crime analysis and mapping project after funding is in place to support the project. The steps can be performed in-house or by a consulting team. They include a needs assessment, functional requirements documentation, data development, system development and testing, installation and testing, user training, planning for future development, and ongoing technical support.

The first task is to complete a detailed Needs Assessment. This process gathers information regarding existing operational procedures, hardware and software, crime data, and personnel needs. It should include interviews of key individuals throughout the law enforcement agency and other related government departments to obtain a comprehensive view of the agency's operations, and where GIS might improve them. Basic GIS concepts should be discussed and illustrated to those interviewees that have little prior understanding of GIS or crime mapping.

A comprehensive Needs Assessment should then be compiled from the results of the interviews. This document explains the various requirements for a crime analysis and mapping system in the following areas: personnel needs, spatial data development needs, tabular/incident data development needs, applicable spatial and temporal crime analysis techniques, basic system requirements, including preliminary, general hardware and software recommendations, and training needs.

The second task is to develop a functional requirements document for the proposed system. This document should describe, as completely as possible, all of the technology and functionality that is to be included in the crime analysis and mapping system. This document is used by the law enforcement agency and its consultant as the blueprint for the application and/or system. It should include the following:

- Hardware specifications
- Software purchases
- Detailed descriptions of work-flow, and examples of the graphic user interfaces
- Describe each tool that is part of that graphic user interface, and its functionality
- Describe how data would flow between the different databases and data warehouses, if applicable
- Describe the redundant security measures that will be put in place to make certain of data integrity and confidentiality, when applicable

- Analytical techniques that the application/system provides the user for incident investigation
- Describe each of the potential products (reports, maps, charts, summary tables) that the user will be able to generate within the system

The third task should be to compile or develop a law-enforcement-specific spatial data set that can be used by the evolving crime analysis and mapping system. Data can be gathered from a number of online sources, as well as county departments. The data layers gathered and maintained should match at least the minimum list provided in Section 1 of this document. At this point, the method of data collection and attributes collected pertaining to an incident should be studied and modified as needed. This might require changes to the agency's RMS (record management system). If changes are warranted, it will be worthwhile in the long run to compile additional information for analysis.

On completion and acceptance of the functional requirements document and the development of the spatial and attribute data, the system development and test phase can begin. During this time, the application will be developed as it was outlined in the functional requirements phase. The law enforcement agency should require periodic reviews of the application at particular milestones, such as 50% and 75% completion. This will make certain that problems with the application will be recognized early in the development process, and that the law enforcement agency remains a part of the development process throughout the project timeline.

When the system is nearing 100% completion, it should be installed and tested in the environment in which it will ultimately be used. This allows the users to test the system alongside the application developers, and determine any system integration problems that might arise. It also gives the developers the opportunity to test the application's functionality in a real-world situation. This testing process should be as comprehensive as possible. Each process detailed within the functional requirements should be tested and evaluated at this point.

User training commences once the application reaches 100% completion and is fully documented. Different levels of tutorials and system documentation should be developed depending on the hierarchy of users. Time should be spent at this stage of the project with each potential user of the system to make certain that the proper education occurs. Training should be done through lessons that use real-life examples of system application. This strategy greatly enhances the users' ability to apply the functionality to their jobs.

The next phase of the project should include a document that describes a future plan for wider system development. This document accomplishes two goals. The future plan gives the local government agency ideas on how the system might grow to assist other facets of its business practices. Secondly, it provides the agency with a ready-made grant proposal for applying for potential funding sources.

The final phase of a successful crime analysis and mapping system is ongoing technical support. The law enforcement agency should always include this contingency within its cost estimates of a project for a minimum of three months after a system has been put into place. No matter how effective an application appears, problems and system changes inevitably impact the functionality of a system.

12. Estimated time line and/or implementation (stand alone) schedule:

Phase	Duration
RFP/Contract process (construction, posting, proposal acceptance, review, award of contract)	4 months - 1 year
Needs Assessment	1 month
Functional Requirements	1-2 months
Data Development	2-3 months
System Development and Testing	2-4 months
Installation and Testing	1 month
User Training	½ month
Plan for Future Development	¼ month
Ongoing Support	3 months

13. Best Practice Examples in Virginia

Fairfax County
Police Department
4100 Chain Bridge Road
Fairfax, VA 22030
703-246-2195
http://www.co.fairfax.va.us/ps/police/homepage.htm

University of Virginia Police Department
2304 Ivy Road
Charlottesville, VA 22903
434-924-7166
http://www.virginia.edu/uvapolice/

City of Newport News Police Dept.
2600 Washington Ave.
Newport News, VA 23607
www.ci.newport-news.va.us/police/beatmap.htm

Virginia Institute for Justice Information Systems (VIJIS)
RECAP Program
http://vijis.sys.virginia.edu